How are nutrient levels maintained for proper plant growth while keeping a healthy soil?

EDIBLE GARDEN PROGRAM (6-8)

Nutrient Management

(ILS 12A, 12B, 13B)

Overview

The key question for this activity is, "How are nutrient levels maintained for proper plant growth while keeping a healthy soil?" And there is no better way for students to answer that than to grow and cook their own food. Using the garden and kitchen as the facilitators, they will inspire student inquiry and teach them about Sustainable Agriculture, specifically, local food production and consumption.

For the purpose of this curriculum sustainable agriculture shall be defined as follows: “Sustainable Agriculture is a system of food production, supported by consumers, where farming operations, practices and technologies *work in harmony* with the natural systems that sustain life on earth.”

Suggested Grade Level

This curriculum is designed for middle school/junior high grade levels. The topics covered can be built upon in complexity throughout that age range.

Approximate Time

This activity requires two, 60 minute sessions and one 30 minute session.

Objectives

1. The students will learn that nitrogen (N), potassium (K) and phosphorus (P) must be present in a certain ratio and quantity in the soil for healthy crop production.
2. The students will learn that N can be added to the soil by planting a crop of nitrogen-fixing legumes prior to planting the production crop.
3. The students will learn that K and P can be added to the soil be adding green waste compost.

Activity Abstract

Students will design a game for them to play using the soil nutrients nitrogen (N), potassium (K) and phosphorus (P). They will learn the N-K-P nutrient ratio requirements for growing pumpkins and how to add those nutrients to the soil using nitrogen producing legumes and adding composted green waste. The game design will be created by the students, using either a game board and components or by using a playing field and necessary props.

Background Information

Good soils are essential for successful crop production. To be profitable, growers must manage soils to provide adequate and properly balanced nutrients. This must be done with minimum loss of soil through erosion and minimum movement of nutrients into ground or surface water. A healthy population of bacteria, fungi and other soil organisms is also important in producing healthy crops. To optimize yield and quality of farmed crops requires a basic understanding of soil and nutrient management.

There are thirteen mineral elements which are essential for plant growth. Six of these are called **major** or **macro** elements because the plant uses them in rather large amounts. They are nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg) and sulfur (S). Sometimes Ca, Mg and S are referred to as secondary elements because they are used in somewhat smaller amounts than N, P and K.

In addition to mineral elements, carbon (C), hydrogen (H) and oxygen (O) are essential elements. Plants take these elements from air and water. We don’t apply fertilizer materials to the soil in order to supply C, H and O, but our soil management practices have an effect on their availability.

In this activity, the class will focus on N, P and K. **More information on these three major elements can be found in Appendix A.**

Materials

- Nutrient Management Cycle handout for each student (See Appendix B.) Pumpkin is the crop example.
- Nutrient Management Cycle transparency (made from handout)
- Scissors
- Thin cardboard
- Felt pens
- Large piece of cardboard or poster board (for game board)

Procedure (Session 1)

1. Find out what the students know about soil nutrients. Ask them the following questions and write the answers on the board: What are soil nutrients and why are they important for plant growth? How do the nutrients get into the soil and what happens to the nutrient levels in the soil after the crops are harvested? How can the nutrients be replaced in the soil after they have been removed by the crops?
2. Pass out the Nutrient Management handout to each student, and display the transparency.
3. Have an open discussion about each component of the Nutrient Management Cycle. Allow for questions and comments. (Review the background information and Appendix A!)
4. With the handout, have the students divide into 5 groups. Each group is to design a game using the Nutrient Management Cycle. The game should meet the following criteria:
    - It can be a board game or played on a grass field.
    - The object of the game is to keep the levels of N, K, and P in the soil in the proper ratio for the healthy production of pumpkins.

Teacher note!
The discussion should contain the following points:

a. Nitrogen-fixing legumes add nitrogen to soil. The legumes need to be planted the year before planting the crop. This can be done by using part of the garden for production crops and the remainder for legumes.
b. Compost adds potassium and phosphorous, as well as organic matter.
c. Using the worksheet example, pumpkins need a N:K:P ratio of 5:6:1available in the soil for proper production.
d. Plant residue and scraps can be composted and added back to the soil for the next growing season.
e. How do they replace the N, K, and P lost from the Nutrient Cycle by the consumption of the pumpkin pie in the handout?

    When playing the game, if the ratio is not maintained then the crops won't produce as well. How do they replace the N, K, and P lost from the Cycle from the pumpkin pie in the worksheet?
  - The ratio to be maintained for N:K:P is 5:6:1, the ratio required to grow pumpkins.
  - Nitrogen is the symbol (N), Potassium is (K) and Phosphorous is (P).
  - Every student in the class must participate in the game.
  - Board game components and field props will be made out of thin cardboard and decorated with felt pens.
5. Give each group will need 20 - 30 minutes to design their game. (They are not creating props and materials at this time.) Have each group share their game idea with the class in another session.

Procedure (Session 2)

1. Have each group present their game design to the class; note each group's design criteria on the board.
2. In a group discussion, establish the class criteria for the best game. It might be helpful to have the Nutrient Management Cycle transparency showing during the class game discussion.
2. Choose one game to create as a class. It can be a hybrid of several games or one group's design.
4. Divide the class into work team groups and split up the tasks for completing the game. Have the groups make the game board and components or props for the field game.

Procedure (Session 3)

1. Have the students set up the game and play it, several times if possible.
2. Allow students to change the rules to more accurately reflect the N cycle, if the class agrees.
3. Have students write a summary of their nutrient management game and what they learned from designing and playing it.

Extensions (optional)

1. Cation Exchange and soil pH information. Suggested for 8th grade.
http://www.umassvegetable.org/soil_crop_pest_mgt/soil_nutrient_mgt/soil_basics_II.html

2. Wonderful charts full of facts about nitrogen fixing plants being used as fertilizer.
http://ipcm.wisc.edu/pubs/pdf/fastfactsweb.pdf

References

http://www.umassvegetable.org/soil_crop_pest_mgt/soil_nutrient_mgt.html

http://www.umassvegetable.org/soil_crop_pest_mgt/soil_nutrient_mgt/compost_use_soil_fertility.pdf

http://www.msue.msu.edu/msue/imp/modf1/06029707.html

Appendix A: Background Information on N, P and K.

NITROGEN (N)

The Nitrogen Cycle. Despite the fact that the earth's atmosphere is 78% N, free gaseous nitrogen cannot be used by higher plants. They depend on N that is present in the soil. To enter living systems, N must be "fixed" (combined with oxygen or hydrogen) into compounds that plants can use. A certain amount of atmospheric N fixation is done by lightning and some by cyanobacteria (blue-green algae). But most nitrogen fixation is performed by soil bacteria of two kinds: those that live free in the soil and those that live enclosed in nodules in the roots of certain leguminous plants (e.g., alfalfa, red cover, birdsfoot trefoil, sweet clover, soybeans, peas, snap bean and lima beans). Four our purposes we will address only those attached in nodules to the roots of legumes.

The "fixed" N is assimilated by bacteria living symbiotically in legume root nodules. The bacteria use atmospheric N in their growth and development. Some of this "fixed" N is available directly to the host plant and some is excreted into the soil where it is available for plant uptake. When the bacteria die and the nodules decompose, additional N becomes available. Because of this N fixation by the bacteria, leguminous crops do not usually need or respond to applied N fertilizer.

Managing Nitrogen (N) in the Soil. Good N management involves supplying the right amount at the right time for crop needs. Lack of sufficient N can reduce yields, but any N in excess of crop needs is subject to leaching. In some crops, such as corn, application of excess N is simply a waste of money, costing a grower as much as $30 to $60 per acre (depending on the N source) without any benefit. With other crops, over-applying N can also suppress yields or quality. In studies in New York and Massachusetts, pumpkin and butternut squash yields were reduced by applying more N than required by the crop. High levels of N can increase the incidence of blossom-end rot in tomatoes and delay maturity of onions and potatoes. By using legumes to full nutrient advantage, you can save money on fertilizer. These crops also improve soil structure and moisture-holding capacity, allowing more efficient use of the native fertility of the soil.

PHOSPOROUS (P) AND POTASSIUM (K)

Using Compost. There are many sources of P and K available to apply to farm fields. In some instances the natural level of these elements in the soil eliminates the need to add any more. Since compost has many benefits beyond nutrient value we will use it for the P and K source for nutrient management in this activity. In addition to P and K, compost also improves soil characteristics such as moisture retention, microbial activity, and permeability. These added benefits are covered in more detail in the Soil Conservation Activity in this curriculum.

Appendix B. Nutrient Management handout.